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Participatory Evaluation of Water Harvesting Techniques for Establishing Improved Mango Varieties in Smallholder Farms of Mbeere District, Kenya

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ABSTRACT

A participatory on-farm study was conducted in Mbeere District, Kenya, in 1996/97 to evaluate the effectiveness of two microcatchments (V-shaped and diamond shaped), and conventional planting holes in the establishment of improved/exotic mango varieties under farmer management. The study area is characterised by low erratic rainfall (600 - 700 mm yr^{-1}), which is received in two seasons. Two types of microcatchments, V-shaped and diamond-shaped, were tested and compared with simple holes commonly used for tree planting by farmers in the area. Grafted mango varieties tested were Tommy Atkins, Van Dyke, Haden, Kent and Apple.

Researchers designed the trial, laid out the microcatchments but farmers were given a free hand to manage the trees. Assessment's done three months after planting showed high survival (>70%) in all cases, except for Van Dyke in the V-shaped microcatchment which had a survival rate of 65%. This was encouraging, as this season was characterized by drought. Through their own initiative, farmers protected, watered, mulched, and used bottle-feeding and shading methods to increase moisture availability to the young trees.

These methods, however, masked the actual effects of the microcatchments but further assessments demonstrated that modifications were randomly applied. Adoption of these moisture conservation techniques indicated farmers' awareness of the negative effects caused by moisture stress and possibly high value attached to fruit trees. Rankings by farmers identified the V-shaped microcatchment as the most effective in terms of moisture retention and labor requirements and was thus recommended for establishing improved mango varieties.

INTRODUCTION

Fruit trees are an important component of the farming systems of semi-arid regions of Mbeere District, Kenya (DAREP, 1994). Mango (*Mangifera indica* L.) is a popular fruit grown in the region for family consumption and for cash generation Most farmers grow the local (naturalized) varieties, which have some limitations, such as low quality fruit (fibrous containing large seeds), limited marketability and develop large dense canopies, casting heavy shade. Because they are usually intercropped within the cropland, much space for crop production is lost (Mugwe et al., 1998). The aforementioned limitations can be addressed through introduction of high yielding grafted (dwarf) varieties (Gachanja and Ilg, 1990) which produce fruit of high quality and at the same time avail more land for crop production.

Moisture stress, however, remains a major constraint. Semi-arid areas are characterized by low poorly distributed and highly variable rainfall and it is almost impossible to plant trees in these areas without some form of water management (Rocheleau et al., 1988). Insufficient moisture greatly hinders tree development and survival; roots are still relatively shallow and young trees cannot take advantage of deeper ground water. Of the few options available, water-harvesting technology is currently the most economical means by which survival of young seedlings can be enhanced (Hai, 1996). Most of the work on water harvesting in Kenya has, however, been carried out in large afforestation programs mainly for general-purpose tree species establishment. Work on fruit trees from farmer perspective is limited. Moreover, adoption of water harvesting techniques by farmers is minimal. The aim of this study, therefore, was to evaluate the effectiveness of two microcatchments and conventional planting holes for the establishment of improved mango varieties under farmers' conditions. Performance of the mango varieties would be evaluated after establishment. Since these varieties will be grown under agroforestry systems, it was important to characterize the farms.

The underlying hypothesis was that microcatchments would improve the survival and subsequent performance of the improved mango varieties.

METHODOLOGY

The study was carried out in Cambia catchment, one of the catchments earmarked for concentrated soil conservation activities by Soil and Water Conservation Branch (SWCB) in the Ministry of Agriculture, Livestock development and

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marketing (MALDM). It is located in Gachoka Division of Mbeere District. This catchment is served by two major dry riverbeds. Soils are predominantly of two types; Rhodic Ferralsols and Luvisols (FAO, UNESCO). They fall under Oxisols in USDA classification (Landon, 1984) both of these soils have high sand content, are shallow hence highly erodable. Annual rainfall ranges between 600-700 mm yr^{-1}. It is usually erratic and of high intensity.

The major food crops grown include cereals (maize, millet, sorghum) and legumes (beans, cowpeas, green grams, pigeon peas). The catchment lies within the marginal cotton zone, Agroecological Zone 4 (Lower midlands 4 - Jaetzold and Schmidt, 1983). There are 106 farms and 80% of the catchment is cultivated with land holdings varying from 0.4-10 hectares. Slopes range between 6 and 25 %.

Trial farmers were selected with the help of extension personnel from SWCB. Before commencement of the trial all farmers were taken to a demonstration site in the Mwingi District, Kenya (semi-arid), where they were able to observe fruit trees (mango, pawpaw, guava) being grown using microcatchments. Initially twenty-five farmers were selected to participate in the trial but eight were dropped due to unavailability of adequate space for laying the experiment.

Table 1. Distribution of household sizes among trial farmers.

Range*	No. of farmers	Farmers (%)
< 5 members	1	6
5 ≤R< 6 members	5	31
6≤R<8 members	6	38
8≤ R< 10 members	3	19
>11 members	1	6

*Mean = 7.1; n = 16.

Table 2. Distribution of farm sizes among trial farmers.

Range*	No. of Farms	Farms (%)
<0.7 hectares	5	31
0.7≤ R< 1.5 hectares	4	25
1.5 ≤ R< 2.2 hectares	2	13
2.2 ≤ R < 3.0 hectares	2	13
3.0 ≤ R< 3.7 hectares	2	12
>7.3 hectares	1	6

*Mean farm size = 5 acres; Standard deviation = 4.8 acres; n=16 .

Table 3. Crops grown among trial farmers.

Crop	No. of farmers	Farmers (%)*
Beans	16	100
Maize	16	100
Millet	6	38
Sorghum	5	31
Catha edulis	4	25
Cowpeas	3	19
Others	5	31

*The total percent adds to more than 100% because farmers grew more than one crop.

Household sizes were observed to be generally large ranging from three to eleven members in a household (Table 1). Majority of farmers had between six and eight members and a mean household size of seven members. The farm sizes within the trial farmers were variable ranging between 0.75 acres to 20 acres with a mean of 5 acres (Table 2). Most farms were less than four acres.

Farmers were found to grow a wide variety of crops (Table 3). Maize and beans are the staple foodcrops and were grown by all farmers (100%). Dryland crops i.e., millet, sorghum, cowpeas and cotton were also important, as this is semi-arid environment. *Catha edulis* (Miraa), a local stimulant is gaining importance as a source of cash.

The trial was a "researcher designed" and "farmer managed" on-farm trial with 17 farmers initiated in November 1996. Treatment factors were the different microcatchments and the mango varieties while farmers were the replicates. The microcatchments tested were V-shaped and Diamond-shaped and were compared with ordinary hole (60 cm x 60 cm) used by farmers while mango varieties tested were Kent, Tommy Atkins, Van Dyke, Apple, and Haden. Each individual farmer planted one tree of every variety in the V-shaped and Diamond shaped microcatchments and ordinary hole making a total of 12 trees per farmer.

The V-shaped microcatchments consisted of two soil bunds arranged in a V-shaped and converging at the region where the planting hole is dug (Fig. 1). Diamond-shaped microcatchments consisted of suitably constructed square-shaped geometric arrangements formed by soil bunds made according to the spacing of the tree (Hai, 1996). The boxes are turned by 45º from the contour (Fig. 2). These microcatchments were modified from what has been described by Rocheleau et al., 1988) to fit what farmers saw at the demonstration site and also to form a closed system for cropping. Assessment was carried out 3 months after planting and a questionnaire was used during the assessments to gather information from farmers on various aspects of the trial.

RESULTS

Survival of mango seedlings three months after planting was good with over 70% in all cases except for Van Dyke in the V-shaped microcatchment, which had a survival rate of 65% (Fig. 3). The V-shaped microcatchment had the best survival overall as there were 69, 50, and 44% of the farmers who had all mango seedlings surviving in the V-shaped microcatchment, diamond-shaped microcatchments, and hole, respectively.

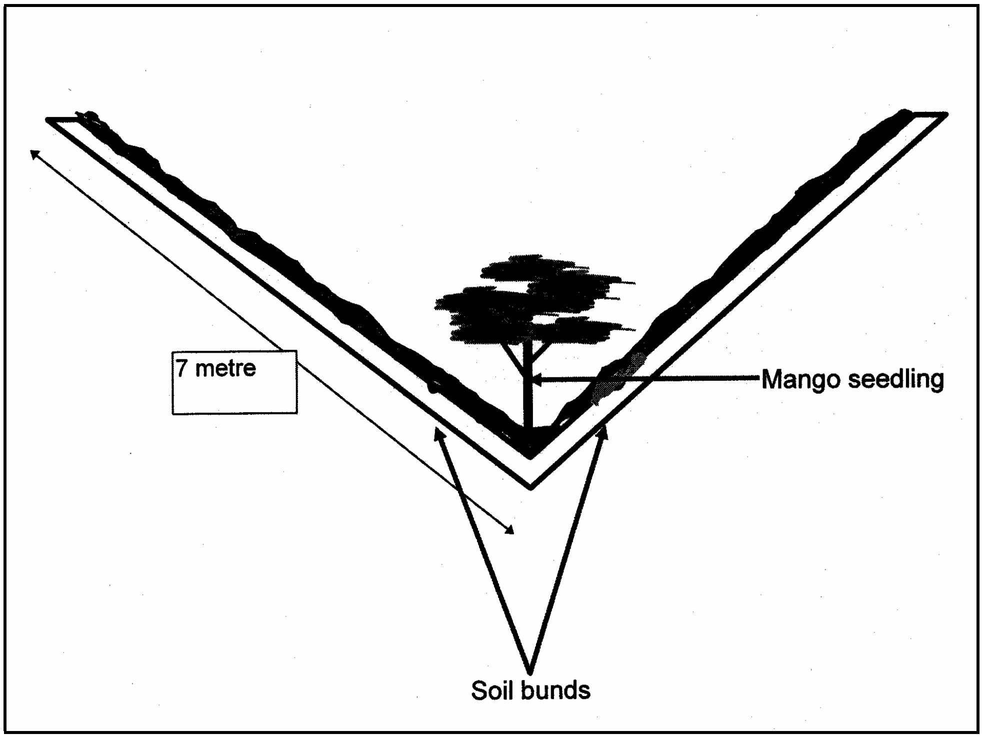

Figure 1. V-shaped Microcatchment.

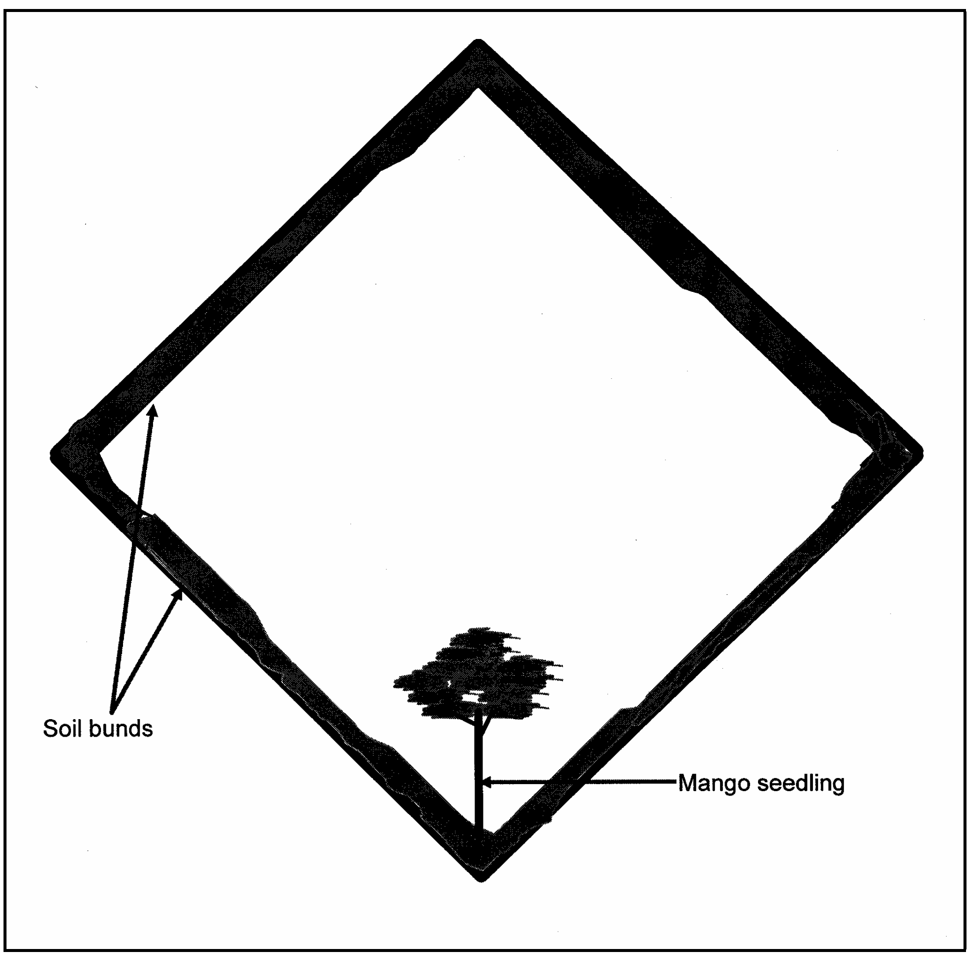

Figure 2. Diamond shaped microcatchment

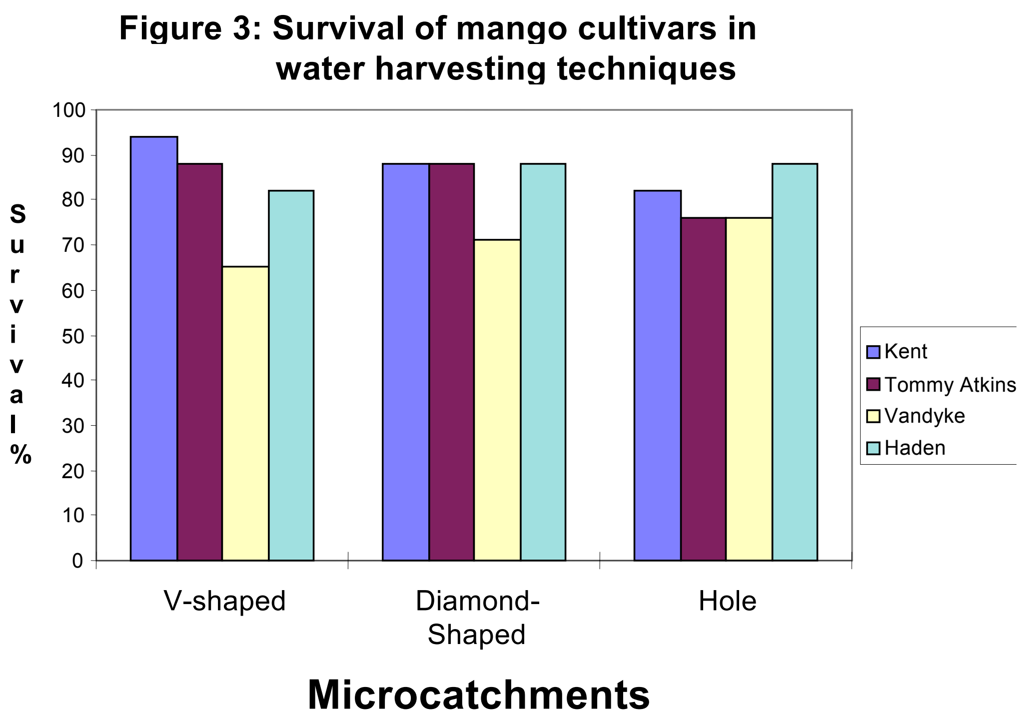
Figure 3: Survival of mango cultivars in water harvesting techniques
100
90
80
70
60
50
40
30
20
10
0
Survival %
Kent
Tommy Atkins
Vandyke
Haden
V-shaped
Diamond-Shaped
Hole
Microcatchments

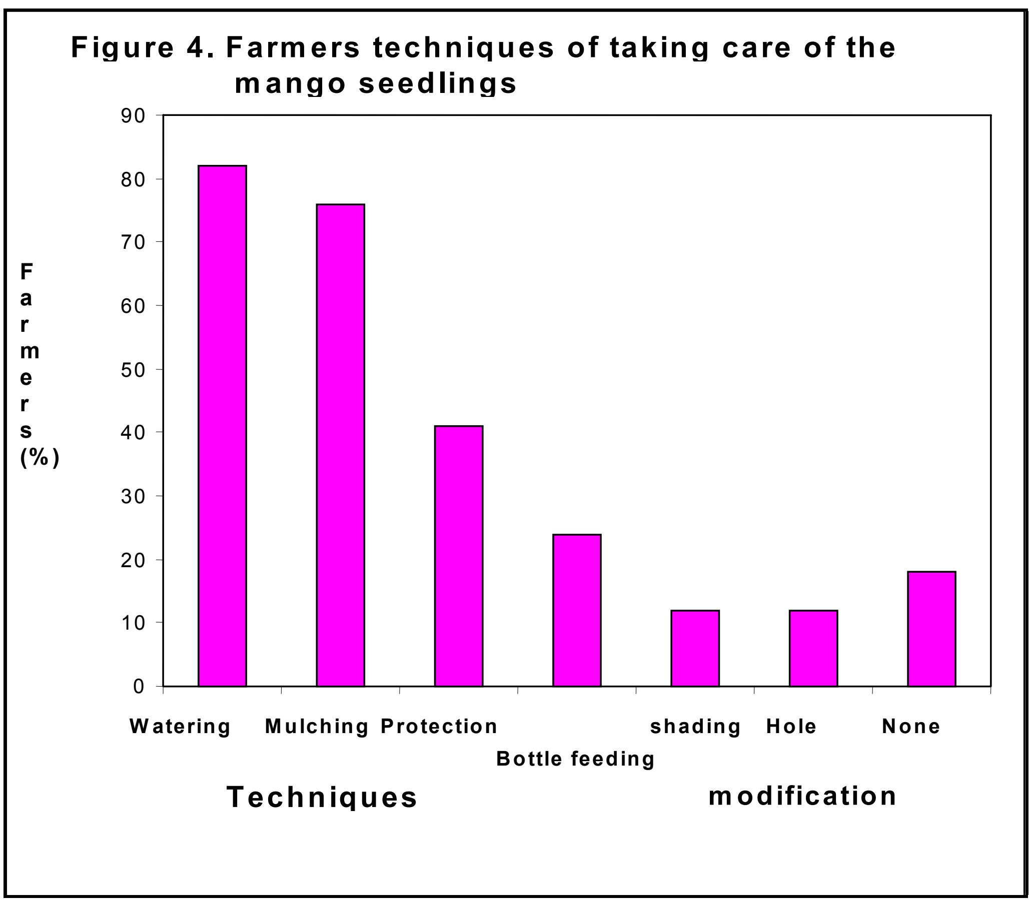
Figure 4. Farmers techniques of taking care of the mango seedlings
90
80
70
60
50
40
30
20
10
0
Farmers (%)
Watering
Mulching
Protection
Bottle feeding
shading
Hole
None
Techniques
modification

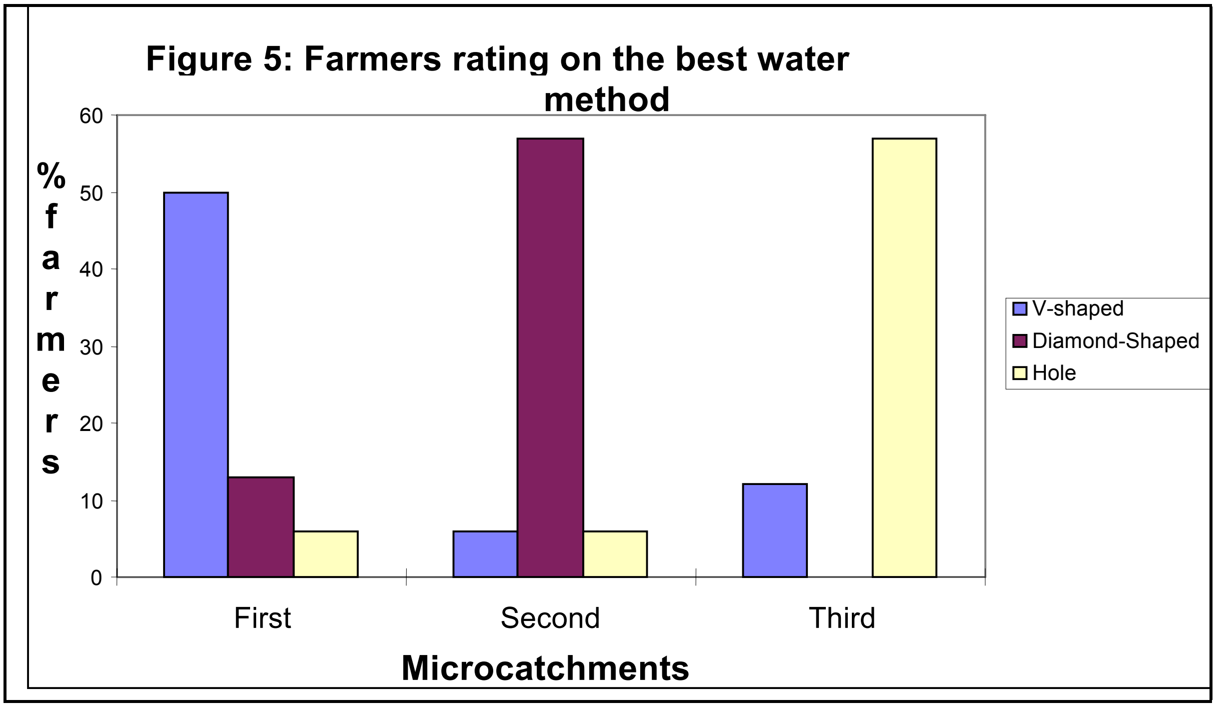

Table 4: Rainfall (mm) in 1996 in Kambita catchment, Kenya

Month	Total rainfall (mm)	No. of rainy days
January	107.1	8
February	71.5	5
March	143.5	11
April	156.7	9
May	57.5	7
June	9.4	5
July	4.6	3
August	2.6	1
September	0	
October	0	
November	28	4
December	9.2	2
January (1997)	3.4	2
February (1997)	0	

Source: Meteorological station at the divisional headquarters NB: The trial was planted in November 1996, highlighted in the table

Statistical analysis did not show significant differences (p=0.05) in survival of mango seedlings in the different water harvesting structures. In multivariate analysis, when the cause of variation in survival was tied to the mango varieties and water harvesting structures, the model accounted for 70% (r=0.70133). This means that 30% of source of variation could not be explained and this was tied to modifications farmers applied to the experiment. Farmers were found to have used a range of techniques to take care of the young seedlings (Fig. 4). This was important in ensuring high survival because of the drought experienced during this season (Table 4). This table shows a total of 40.5 mm received during this season (November, 1996 to February 1997) against a long term average of 400 mm. Watering was the most common technique adopted by farmers followed by mulching. When farmers were asked why they decided to use these methods, they indicated that they highly valued the trees and wanted to have all surviving Farmers rating on the best overall method for planting mango seedlings (Fig. 5) showed that V-shaped microcatchment was best overall. They indicated that V-shaped microcatchment was more effective in trapping rainwater and required less labour compared to Diamond-shaped microcatchment. Conventional hole was said to be unsuitable for tree establishment.

DISCUSSIONS

The high survival of mango seedlings (>60%) observed three months after planting in this study was mainly attributed to farmers using other methods to improve moisture availability to the young seedlings as this was a dry season. The microcatchments were possibly useful during the first few weeks when little rain was received. Seedlings survival in Arid and Semi-arid Lands (ASALs) can be as low as 10% owing to moisture stress (Tiffen et al., 1994). Microcatchments are highly effective in concentrating runoff around the root zone of a growing tree in the critical first and second year until the young trees become well established. Mutai (1986) reported a high survival rate for seedlings planted using modified semi-circular hoops in a dry AEZ in southern Kitui, Kenya. Elsewhere, water harvesting for fruit trees establishment has been successful. For example, Mundanya and Muturi (1997) reported higher survival in W and V-shaped microcatchments than ordinary hole.

On three farms where no modification was done low survival was observed. It is interesting to note that some farmers used more than one technique. This, however, complicated the analysis of the experiment. Even though these modifications adopted by farmers confounded effects of this experiment, it was possible to establish that, through farmers feedback that V-shaped microcatchment was the most preferred. This is mainly because of low labour requirement. The ordinary hole (control) should not be recommended for seedling establishment due to low survival experiences.

Among the techniques innovated by the farmers, mulching with leaves and twigs of trees was common possibly due to their conceived effectiveness and availability of mulching materials. According to Rocheleau et al., (1988) mulching is an effective method of conserving water in ASALs but may be disadvantageous as they might attract termites. Grazing animals are usually a menace to young tree seedlings in semi-arid areas and the farmers protected their seedlings using thorny twigs and sticks surrounding the seedlings. They used a common tree species (*Acacia mellifera*), which is thorny, thus effective in keeping away the livestock.

Farmer's innovations of other techniques to take care of the young mango seedlings might be an indication of the interest in growing fruit trees. Fruit trees are highly valuable in the livelihood of small-scale farmers. They are frequently consumed when in season and are an important source of nutrients especially for children (Rice et al., 1991). When consumed at home they contribute substantially to the health status of consumers (Gachanja, 1993). They can also contribute to poverty alleviation through risk reduction and cash sales of the fruits. Fruit trees are usually ranked first in the choice of woody perennials (Aiyelaabe, 1995).

CONCLUSIONS AND RECOMMENDATIONS

This is a real case of farmer participation in technology modification to demonstrate the prevailing circumstances. Farmers know their environment better and have strategies of copping. We would recommend on-farm testing and validation of technologies developed under controlled conditions (on-station) so as to be able to capture any constraints to adoption. For example in this study Diamond microcatchment was found to require a lot of labour. In introduction of woody species, it is important to introduce what farmers would like because they are likely to take care of them hence efforts are not wasted. In this trial farmers are very enthusiastic about growing the improved mango varieties, which they can use at home or for sale.

Since the major goal was to promote growing of improved mango varieties so as to improve marketability and reduce negative tree-crop interactions on farms, this trial will continue for several years. Now that the trees are established, the aim will be to evaluate their adaptation and performance. Treatment factors will be productivity, growth patterns/architecture and quantification of tree-crop interactions.

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